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AUTHOR Christ, Susann
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ABSTRACT

This paper reviews several issues regarding one-versus two-factor theories of learning. First, the traditional distinctions between classical and operant conditioning are presented. This includes both theoretical and experimental contrasts. Second, empirical evidence in support for a one-factor theory is examined. Numerous research studies involving operant conditioning of the autonomic nervous system are discussed. The basic hypothesis tested in the studies is that involuntary responses may be demonstrated to come under control of operant reinforcers. Thus, the need for only one kind of learning is demonstrable. The studies involve operant conditioning of heart rate, blood pressure, galvanic skin response, brain waves, etc., with both animal and human subjects. The vast majority of the experiments indicate significant results in favor of operant conditioning of the autonomic nervous system. Critics' questions and evaluations of such findings are reported. These generally surround the usage of yoked control design, conditioning versus control mediation. Lastly, the practical significance of experimental findings which suggest a one-factor theory are explored. (Author)

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A Literary Review of One Versus Two Factor Theories of Learning as the Issue Relates to Operant Conditioning of the Autonomic Nervous System

by

SUSANN CHRIST

B.A. Psychology, Southern Illinois University, Edwardsville, 1968. M.A. Psychology, Southern Illinois University, Edwardsville, 1972. Formerly of State Community College, East St. Louis, Illinois, now a doctoral level student in education at St. Louis University, St. Louis, Missouri.

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This paper reviews several issues regarding one versus two factor theories of learning. First, the traditional distinctions between classical and operant conditioning are presented. This includes both theoretical and experimental contrasts. Secondly, it examines empirical evidence in support for a one factor theory. Numerous research studies involving operant conditioning of the autonomic nervous system are discussed. The basic hypothesis tested in the studies was that involuntary responses may be demonstrated to come under control of operant reinforcers. Thus, the need for only one kind of learning is demonstrable. The studies involved operant conditioning of heart rate, blood pressure, galvanic skin response, brain waves, etc., both with animal and human subjects. The vast majority of the experiments indicated significant results in favor of operant conditioning of the autonomic nervous system. Critics' questions and evaluations of such are reported. These generally surrounded the usage of yoked control design, conditioning versus control and mediation. Lastly, the practical significance of experimental findings which suggest a one factor theory are explored.

I

The purpose of this paper is to review the contentions of both one and two factor learning theorists giving special attention to research on instrumental conditioning of autonomic processes and its implications for the above mentioned controversy. This will be accomplished in several ways. First, the postulates involving two factor theory will be explored. For purposes of brevity and specificity the discussion will be confined only to those theorists who distinguished classical and operant conditioning as two distinct processes and the supportive evidence they present. However, it is herein recognized that many twofold classifications of learning have been historically proposed by different authors. Some do not adhere to the same semantic terms and posits for said classifications, for example, Thorndike, Miller and Konorski, etc. (Hilgard and Bauer, 1966.)

Secondly, instrumental conditioning of the autonomic nervous system (ANS) will be explored. This will include review of relevant research in the area. Again, for purposes of brevity and specificity the discussion of one factor theory will be confined to the theoretical framework of those researchers, supporters of ANS operant conditioning. It is recognized other one factor proponents exist who have not specifically investigated this issue (eg. Hull). The issue will be reviewed in terms of critics' as well as advocates' analysis.

Lastly, both therapeutic and general ramifications for ANS operant conditioning, as it relates to one versus two factor theory will be discussed.

II

One of the most controversial issues to imbue the field of learning psychology has been whether learning consists of two factors or types or one factor or type.

First, one must note that much emphasis, both past and present, has been directed at assertion and substantation of what is known as the two factor theory of learning. Many traditional proponents of this thesis have postulated a two-fold classification between classical and operant conditioning that distinguishes them as different types of learning. Classical conditioning is that learning in which the stimulus event preceeds the response and the response is elicited, usually thought of as an involuntary of autonomic nervous system function (Ferster and Perrott, 1968, Bijou and Baer, 1965, O'Connor, 1971, Thompson, 1967). By contrast, operant conditioning is that learning in which the response is first emitted and a reinforcing stimulus follows it, thereby increasing the probability of the response's occurence. Usually it is thought of as a voluntary or central nervous system (CNS) function (Bijou and Baer, 1965, Ferster and Perrott, 1968, O'Connotr, 1971, Thompson, 1967).

Ferster and Perrott (1968) and Keller and Schoenfeld (1950) indicated several other distinguishing characteristics between the "two" types of learning. These were as follows: 1) both stimulus and response in operant and respondent

learning function in opposing directions. An organism's operant performance acts on and alters the environment. In classical conditioning the environment alters the organism; 2) operant acts change the environment external to the organisms; many classical reflexes are limited to internal physiological effects on the organism; 3) both reflex response and operant acts describe behavior and environment separately. The reflex is an unconditioned response elicited by an unconditioned stimulus and the operant is referred to as a performance (e.g. bar press).

This is in agreement with Skinner (1938) whose dictum previously differentiated what he termed "Type S: or classical conditioning versus "Type R: or operant conditioning. He stated:

> ...In a respondent the response is the result of something previously done to the organism; the simultaneous presentation of two stimuli precedes, or at least is independent of, the occurence of the response. The operant becomes significant for behavior and takes on an identifiable form when it acts upon the environment in such a way that a reinforcing stimulus is produced... Conditioning of "Type R" is impossible in a respondent because the correlation of the reinforcing stimulus with a response implies a correlation with its eliciting stimulus. It has been noted that conditioning of "Type S" is impossible in operant behavior because of the absence of any eliciting stimulus (Skinner, 1938, p. 22).

Gagne (1965) asserted the distinction between classical and operant conditioning to be one of the most widely accepted and pervasive. Moreover, Hilgard and Baer (1966) alleged that such two-fold schemas of the above conditioning paradigm have also been theroetized by Miller and Konorski, Schlosberg, Hilgard and Marquis and Mower. In addition, Grant (1967) and Kendler (1968) hold this view.

Also, the writings of many two-process theorists abound with in-depth contrasts between classical and operant conditioning.

For instance, Kimble (1961) proposed that different basic laws of learning apply to the two processes. That is the law of contiguity is associated with classical conditioning and the law of effect with operant. Thus the former is thought to occur resultant of pairing between conditioned stimulus and unconditioned stimulus. In the latter, the probability of the response is increased due to the crucial factor reinforcement.

Murray (1967) noted differences in contrasting determining antecedent stimuli in the two situations. In respondent conditioning there is a fairly simple stimulus event the unconditioned stimulus (UCS) which will evoke the unconditioned response (UCR). In operant conditioning the stimulus conditions originally responsible for the response are unmeasured and unspecified. A second contrast involves experimenter control over the situation. In respondent conditioning it is the experimenter who determines when a reinforced trial takes place. In operant contitioning, the organism's response determines the reinforcing occasion. Moreover, in classical conditioning studies, the subject is often restrained which

minimizes motor and gross movements. In operant conditioning, the subject is unrestrained as the experimenter is interested in gross motor responses that may comprise operant acts.

Other contrasts according to Murray (1967) include the types of response measures employed in each situation. For respondent conditioning this involves response latency, magnitude, and percentage of responses. The major dependent variables in instrumental conditioning are rate of response and distribution on interresponse times. Here the author did not further elaborate on these said differences. He did, however, point to one facet, the similarities between the conditioned response (CR), unconditioned response (UCR). In the case of classical, the conditioned stimulus (CS) and the unconditioned stimulus (UCS) may be diverse in nature (e.g. tone CS, food UCS). Yet the CR and UCR are usually similar (salivation in this instance). In operant conditioning, the responses are usually quite different (e.g. bar press response followed by food pellet S^r).

Similarly, Dykman (1967) also noted the distinction between classical and operant conditioning in terms of the role of the subject. In operant conditioning reward or punishment is contingent upon the behavior of the subject. In classical, the sequence of events if independent of the subject's behavior.

Further, attestations of contrast between operant and respondent conditioning came from physiological psychology. Wrywicka (1972) stated that:

> ... only after the establishment of the conditioned neural pattern does the classical reaction appear before the significant stimulus as a result of the activation of the pattern (stimulus plus reinforcement). ... On the other hand, the instrumental reaction from the very beginning takes place before the significant stimulus is applied (Wyrwicka, 1972, p. 54).

Grossman (1967) asserted the physiological distinctions between autonomic and somatic or central nervous system components on which the two types of conditioning are separately said to function. He believed the autonomic nervous system to be anatomically, physiologically, somewhat pharmacologically distinct from the somatic system. The former is concerned with regulations of visceral functions; the latter with control of striate musculature and sensory inputs from external receptors.

He did, however, elude to an association between the two systems in observing the autonomic nervous system to be intermingled with somatic aspects of the brain and spinal cord. This point may beg the question as to whether certain autonomic responses placed under voluntary control have not been somatically mediated. This issue will be taken up in more depth later (part IV).

By contrast to the aforementioned distinctions instrumental and classical conditioning appear to have some common properties. Kimble (1961) has attempted to delineate such. His position did not appear to be postulation of a one factor theory. Rather it seemed to be illustration of comparisons that warned against exaggerated views contrasting the two learning types. Some of the more important

facts on which the author digressed, included: 1) acquisition, 2) extinction, 3) spontaneous recovery, 4) response generalization and differentiation, and 5) higher order conditioning.

First, with regard to acquisition and extinction, he asserted these variables to be of sufficient familiarity as to require no documentation. The author did list a number of response measures employed in acquisition such as probability of response occurences, response speed, response magnitude, rate of responding and resistance to extinction. One is almost left with the supposition that these measures are analogous to both types of conditioning. As previously mentioned by Murray (1967) the response measures appear different appropriate to the type of conditioning.

Extinction was referred to as a decrease in response strength due to non-reinforcement and is common to both types of conditioning.

Spontaneous recovery referred to the recovery of response strength with rest after extinction has taken place. Here he noted that Pavlovian experiments have demonstrated a reduction of the number of drops of saliva secreted to the CS in extinction. Later, after a significant time interval, salivary secretions to the CS were increased to a level similar to pre-extinction trials.

Similarly, in instrumental conditioning, a rat may be trained to bar press for food reward (acquisition). The experimenter may extinguish the response and after a time level also observe an increased rate of responding.

With respect to response generalization and differentiation several examples were utilized. Under response generalization it has been noted that when an organism has learned to respond in a particular way to stimulus A, it will learn to respond in a similar manner to an almost equivocal stimulus A'. For example, in classical conditioning an organism may respond to the CS with another hand or foot when the one previously employed was incapacitated. Likewise, instrumental responses may show comparable data. It was noted that rats trained to bar press where 21 grams of pressure were required to obtain food under one condition and 38 grams of pressure in another, showed response generalization as illustrated by the variability in pressures.

Response differentiation in classical procedures may be illustrated with respect to eyelid conditioning in which a response tendency is acquired so that the blink is timed to anticipate the onset of the UCS. The author did not further elaborate. He did assert that more extensive examples of response differentiation have been illustrated in operant procedures including studies of restricted values of response intensity, duration, and rate. One is again left to assume that the consequences of response differentiation are somewhat comparable under either of the two factors.

Lastly, with regard to higher order conditioning, the author purported that in classical procedures it is possible to use the CS as the UCS for further conditioning of a salivary response. For example, if the original CS was an aucitory stimulus and the CR to this stimulus was firmly established, a black square may be presented briefly before it. After a number of pairings of the square and the auditory stimulus, a salivary response may occur to the square. This is higher order conditioning.

A similar procedure in operant conditioning involves the establisment of a secondary reinforcer. This amounts to pairing a neutral stimulus with another stimulus, that serves as a reinforcer. For instance, rewarding chimpanzees with poker chips for certain responses, which may be used in another apparatus to produce food.

Aside from noting comparisons and contrasts of the two types of learning, other theorists have attempted to examine the interactions between them. For example, Staats (1970) asserted that although the underlying principles of the two factors are discussed separately, it is possible for the same stimulus to serve both a classical and instrumental function. Curiously enough, a UCS may elicit an emotional response, but also have reinforcing properties which could serve to condition operant motor acts.

Accordingly he stated that:

> ...when a neutral stimulus is paired with a UCS that elicits an emotional response, the neutral stimulus will come to elicit the emotional response. ...the UCS by virtue of eliciting the emotional response will also be a reinforcing stimulus...in the classical conditioning process, as the neutral stimilus comes to be a CS and elicit the emotional response, it also comes to serve as a reinforcing stimulus. ...The neutral stimulus in the pairing process acquires several functions of the stimulus with which it is paired. ...it becomes a conditioned reinforcing stimulus. This may occur in the negative case, where the stimulus will elicit a negative emotional response and also serve as punishment, or in the positive case, where the stimulus will elicit a positive emotional response and serve as a reward (Staats, 1970, p. 211).

Similarly, Ferster and Perrott (1968) pointed out that elicited reflexes may come under the control of operant reinforcement. For example, an infant's crying is reflexive and may originally be elicited by a loud noise. Later, it may come under the control of a reinforcer since it changes the child's environment (e.g. infant cries, mother provides milk, a reinforcer).

They further believed the distinction of the two procedures as mediated by differing nervous system components is not viable. This is due to the fact that striated muscles (mediated by CNS) may be inclusive in either relfex or operant performance. For instance, the thigh muscles will raise a leg in an operant act that is reinforced, or as a reflex exerted by a knee tap. They did not, however, propose a one factor approach. Rather it appeared they were pointing towards instances of mixed models maintaining at least a procedural distinction between the two factors.

Kanfer and Phillips (1970) also noted the possibility of mixture of operants and respondents in agreement with Staats (1970) and Ferster and Perrott (1968).

In addition, Bugelski (1956) lended an account of Mowrer's two factor theory of avoidance learning. In line with the theories previously purported it illustrated how both factors may become involved. The CS in this context becomes associated with the UCS by Pavolvian conditioning. Next the stimuli from the pain - fear complex result or lead to the instrumental avoidance response that is reinforced by the reduction of the fear drive.

In capsulizing the aforementioned theories Walker (1967) posed the question as to whether contiguity of stimulus and response are satisfactory components for learning or does learning need involve reinforcement? Continguity, is associated with classical procedures and reinforcement with operant as previously noted. Of course an affirmative answer to this question in either direction would vow support for a one factor theory. The author, however, listed three main approaches or stances with regard to the issue. These were as follows: 1) the continguity principle may be chosen as the most parsimonious explanation of learning, and one must then explain facets of selective learning minus reinforcement; 2) the two factor theory may be asserted in that some learning involves both continguity and reinforcement; or 3) one may assume that reinforcement essentially underlies all learning.

The author contended that substantiation of the last approach may be accomplished with the most ease. That is, classical conditioning may be accounted for through reinforcement procedures. In most classical conditioning research there is some incentive entity that could serve as a reinforcer (e.g. meat powder). Or in the case of avoidance and escape, an aversive stimulus such as shock is present, the termination of which becomes reinforcing.

In summation, a number of comments appear orderly. Proponents of the two factor theory appear to embrace a basic distinction between operant and classical conditioning as two entirely different types of learning. The distinction is not merely procedural in most cases. Rather it involves an interrelationship between experimental procedure and the anatomical functions involved, albeit two distinct nervous systems analogous to two distinct forms of conditioning.

Secondly, some theories posit that while the two factors are distinguishable, both are necessary to explain the multiplicity of stimulus situations involved in an organism's world (e.g. mixed models or interaction models).

Third, others while maintaining the notion of two types of learning have raised partial questions as to the extent of their distinctness and even attempted to draw parallels of one with the other.

Lastly, and most critically, one must admit with reluctance that the literature on one versus two fact theories appears almost scanty. In most instances the proponent of either thesis abounds his essay with hypothetical examples of support for his side. Cross examinations and experimental evidence are frequently excluded from discussion.

Moreover, many theorists have not directly dealt with the notion of two factors in conjunction with experimental evidence that may support a one factor approach.

III

Perhaps the most profound denounciation of two-factor theory in recent times came from Miller (1973) and Di Cara (1971).

They pointed out that traditional learning theorists have distinguished between autonomic or classically conditioned responses and central nervous system responses which are learned through instrumental conditioning. Their antithesis was that these assumptions are invalid, and there is but one kind of learning.

This argument was developed through a series of experiments which tended to illustrate operant control of involuntary functions.

According to Di Cara (1971) research of this nature is difficulty to control due to the fact that many visceral responses can be affected by voluntary activity such as muscular tension or breathing rate. In short, the experimental subject may learn to perform a voluntary response that exerts control over the involuntary behavior mentioned. Accordingly, Miller and DiCara attempted to control for this by using a drug, curare, which paralyzes the skeletal muscles, but does not interfere with consciousness or transmission of autonomic responses.

Utilizing curarized rats a number of experiments were performed austensibily indicating that learning a visceral response was amenable to various operant laws. Briefly, these included such variables as shaping, discriminative stimuli, stimulus discrimination, retention, and extinction.

During "time in" periods rats learned to accelerate or decelerate heart rate when the criterion was set at continuously higher levels, thus shaping to a twenty per cent increase or decrease over baseline. In addition, the subjects learned to respond to light and tone stimuli, indicating capability of the response to be brought under the control of a discriminative stimulus. Moreover, the subjects demonstrated stimulus discrimination as they later learned to respond to the light for its positive stimulus values and not to respond to the tone for its negative values.

Lastly, retention studies (three months later) indicated changes in the direction the subjects were previously reinforced. Extinction was also reportedly demonstrated (Di Cara, 1971).

The aforementioned studies were performed with brain stimulation serving as a reinforcer. To determine whether there was anything exceptional about this variable as a reinforcer rats were successfully trained to increase or decrease heart rate as a measure of avoidance and escape from electric shock.

Learning of both heart rate and blood pressure was also demonstrated in the noncurarized state (Di Cara, 1971).

Other issues which would cast doubt on the experimental results were examined. Namely, these are: 1) that changes were due to an overall arousal pattern or impulses from higher brain centers; 2) that centralized impulses might be particularly directed toward muscles that control the heart (for example) when heart rate is reinforced.

With regard to the first issue Miller and Banuazizi compared operant conditioning of heart rate and intestinal contraction to determine if said learning could occur independently of a general arousal pattern. These two responses were chosen because of their physiological interrelatedness and thus corollary of effect. The results indicated that curarized rats demonstrated an increase or decrease of intestinal contraction in the appropriate direction. No concomittant changes in heart rate were observed. In fact the two measures appeared to be negatively correlated (Di Cara, 1971).

For rebuttal of the second issue that central impulses might be selectively controlling muscles which in turn affect the function under research, rats were trained in the curarized state and tested in non-curarized state. Presumably if heart rate changes had been mediated by central impulses to skeletal muscles said muscle movement would appear in the non-curarized state. Such was not the case as transfer of training reportedly took place independent of muscle movement.

In addition, other studies of instrumental conditioning in urine formation, peripheral vasomotor functions have demonstrated specificity of response. That is, they did not seem to be correlated with heart rate, blood pressure changes, etc. (Miller, 1973).

Moreover, Miller (1969) postulated the results of his research to demonstrate a number of other autonomic responses may successfully be subjected to instrumental control. Chief among them are gastric changes, blood pressure, brain wave patterns. The instrumental learning of these responses and those previously mentioned may be accomplished with the human organism as well (Miller, 1969, Miller, Di Cara, Solomon, Weiss, and Dworkin, 1970).

Similarly, other investigators have manifested comparable results when attempting to condition involuntary responses instrumentally.

One such example was operant conditioning of brain wave patterns. Kamiya (1968) attempted to control alpha rhythms. Subjects were placed in a darkened room and instructed to close eyes. Electoencephlogram (EEG) recordings were monitored continuously. At the sound of a bell subjects were to guess whether they were in state A (alpha) or state B (non-alpha) and were then informed as to correctness of their response. The majority of subjects reached a significant proportion of correct guesses.

In another experiment Kamiya (1969) investigated the possibility of subjects learning to control alpha waves without first going through discrimination training. A tone was presented contingent upon the appearance of alpha waves. When the alpha waves stopped so did the tone. Subjects again seated in a darkened room were instructed that particular mental states produced the tone. They were encouraged to sustain it and at the end of each one minute trial were informed as to percentage of time they were successful. After five trials to criterion, the task was reversed and subjects were asked to suppress the tone. After forty testing periods it was revealed that eight of the ten subjects were able to control the tone.

In totality, Kamija (1968) posited that tests with over one hundred subjects indicated eighty to ninety per cent have learned to produce and control alpha waves.

As a point of interest, control of EEG activity is not entirely novel. It has been known for sometime and substantiated that Zen meditations and Yogis have altered their brain wave patterns (Kasamatsu and Hirai, 1969, Anand, Chhina, and Singh, 1969, Speeth, 1972).

In addition, Brown (1970) reported specificity of EEG Alpha responses to a light signal situation as compared to the identical situation without the light. Subjects were instructed to exert identification of feeling states that would maintain the occurence of a blue light monitored by the presence of alpha activity. The results indicated that sixty percent of the subjects learned specificity of response and thus to control the production of alpha waves. Of special interest to the investigator was the fact that subject's verbal reports indicated the largest increments in alpha waves were manifested by those subjects who lost awareness of all other environmental factors, but the light. Hypotheses which might account for this phenomenon were not discussed.

Similarly, Glazer (1974) reported instrumental conditioning of theta waves. Rats were placed on a fixed-ratio (FR) 5 schedule of reinforcement. One group was trained to produce theta, another non-theta, while the third served as a matched (yoked to first group) interreinforcement time control. Acquisition trials were followed by extinction. The conclusions noted that theta production was learned more slowly than non-theta, but the former evidenced increased resistance to extinction.

Other investigators have sought to demonstrate the effects of feedback and/or reinforcement on human systolic blood pressure.

Shapiro, Tursky, Gershon, and Stern (1969) trained one group of subjects to increase blood pressure and a second group to decrease it. For each trial on which the subject was successful a red light and a tone were presented simultaneously, followed by a nude slide from playboy magazine. While most subjects learned to control blood pressure, the largest change was evidenced by the group trained to decrease pressure. No systematic relationsips between cardio-vascular function and blood pressure changes were observed.

In a comparable experiment, Chapiro, Tursky and Schwartz (1970) again rewarded subjects for increasing or decreasing systolic blood pressure. Reinforcement was programmed on a fixed ratio schedule and included slides of nudes, landscapes, and money. Subjects instructed to "increase" evidenced significantly higher blood pressure than "decrease" subjects and controls.

Brener and Kleinman (1970) provided subjects with visual feedback for decreases in blood pressure. In only two short training sessions subjects showed significant decreases in systolic pressure. Again these investigators concluded that heart rate changes did not correspond systematically to blood pressure changes.

Other research suggested that galvanic skin response (GSR) may come under control of reinforcement. Kimmel and Kimmel (1963) rewarded a contingent group of

subjects with a dim light for unelicited GSRs. The non-contingent group received the same number of lights per minute when no GSRs were occuring. The contingent group omitted significantly more responses than did the non-contingent group during both acquisition and extinction.

In a similar manner Stern and Pavloski (1973) rewarded subjects with a light for unelicited vasoconstrictions. Significant differences were obtained between experimental and yoked control subjects in favor of the experimental group.

Moreover, Hefferline and Perera (1963) reported successful proprioceptive discrimination of a covert response without subject's complete awareness. When subjects omitted an invisibly minute thumb twitch they received a tone signal to press a key which in turn revealed a score of correct responses on an illuminated digital display. The subjects were not informed as to which response was being conditioned. In extinction no tone (SD) was present and the experimenters indicate the key response was resistant to extinction.

Even more startling was an attempt to control single motor units. Basmajian (1963) undertook operant conditioning of specific muscle contractions. Proprioceptive feedback for the subjects included hearing their motor unit potentials and seeing them on monitors. Most of the subjects achieved better willful control over gentle contractions. It was also discovered that they could repress one motor unit they had become familiar with and recruit another. Although the responses involved consisted of motor units of skeletal muscle, they are not typically considered voluntary functions.

IV

Contrary to the fact that research evidence seemingly supports instrumental conditioning of the ANS, it has come under much scrutiny and skepticism from traditionalists.

Chief among the critics are Katkin and Murray (1968). They attempted to delineate methodological flaws and systematic biases which may contaminate the findings. Several issues came to the fore. Namely, these concerned medication, the yoked control, and conditioning versus control.

With regard to mediation it was hypothesized that involuntary control is not exercised directly, but it is chained to a mediating voluntary operant. There are several ways in which ANS conditioning might be found to be a secondary aspect linked to skeletal or previous classical conditioning. These are as follows:

1) The ANS response may be a UCR to an external source of stimulation (e.g., individual sticks self with pin and causes GSR to change, if GSR response is reinforced, it can lead to GSR conditioning.

2) An ANS response may be a UCR to an internal source of stimulation (e.g., individual may engage in rapid muscular activity that elicits GSRs; if reinforcement is delivered upon detecting the GSR, the subject might show an increase in muscular activity or apparent conditioning.

3) An ANS response may be a CR to an external source of stimulation (e.g. a subject may read an exciting book or look at an arousing picture to which ANS responses have been previously conditioned).

4) An ANS may be a CR to an internal source of stimulation (e.g., an individual may engage in subvocal activity which elicits a previously conditioned ANS response).

In questioning the use of yoked control design the authors noted that such a procedure established an inherent bias against the control group. Individual differences in reaction to a stimulus event or reinforcer may favor the experimental group over its yoked controls. The control subject receives the same number and temporal distribution of reinforcers as their mate with whom they are paired. This procedure has frequently been used in operant studies to illustrate reinforcement effects. But, if the reinforcer is an effective activation for the experimental subject both its response and reinforcements will be frequent. Thus, when the reinforcer isn't an activator for the control subject, his behavior evidences little change. By contrast, if the reinforcer doesn't activate the experimental subject he responds infrequently and thus receives few reinforcers. The control is thus prevented from activation since it too receives few reinforcers, even when the reinforcement is effective. A superior experimental subject can improve at the expense of an inferior control, but a control cannot improve when yoked with an inferior experimental subject.

In analyzing conditioning versus control it was noted that if one's prime goal is more control of ANS, demonstration of pure instrumental conditioning is unnecessary. That is, control may be established through reinforcement of somatic and cognitive mediators. Control may be established independent of an exclusively operant paradigm.

The authors also suggested some minimal criterion for demonstration of instrumental ANS conditioning. First, that the response in question evidence an increased frequency over baseline. Secondly, experimental designs should yield comparisons between experimental and control groups. Lastly, and ideally, the data should remain free of other obvious interpretations.

In line with this hypotheses, it was pointed out that most studies of unelicited GSRs suffer from the methodological flaws discussed. Many experimental results in this context may have been due to mediation. Likewise, experiments involving instrumental control of peripheral vascular responses and cardiac rate suffer from similar flaws, especially those associated with the yoked control design.

Katkin and Murray (1968) did, however, designate several instances of carefully controlled clear evidence for operant conditioning of the ANS. One instance came from the work of Van Twyer and Kimmel (1966). Their investigation concerned the possibility of somatic mediation in GSR conditioning. Respiration rate, irregularity and muscle potentials were controlled. Reinforcement consisted of a light contingent upon a response greater than basal skin resistance. The results indicated no differences between groups due to mediation. The contingent

reinforcement group showed an acquisition curve versus a decay curve in the non-contingent or control group.

The other plausible evidence of instrumental conditioning of ANS came from the animal research of Neal Miller and his colleagues who also made attempts to control for mediation, usually with the drug, Curare (Katkin and Murray, 1968). In fact, Katkin and Murray and Lachman (1969) postulated such evidence from animal studies to be far more convincing than ANS studies of humans with demonstrable flaws in experimental controls.

However, McGuigan (1973) in an even more dubious analysis, criticized the use of Curare to paralyze skeletal musculature. It is purported that evidence exists Curare may not totally paralyze the skeletal musculature. While there may have been no overt responses in this state, minute covert responses might still have occured. In essence, the need was suggested for more sensitive measuring instruments that could detect such covert responses which might act as mediators.

Moreover, Smith (1954) argued that most conditioned ANS responses were but artifact accompaniments of the skeletal responses propagated via the conditioning process. For example, in training the organism regards the CS as a cue for muscular bracing against the coming aversive stimulus. The bracing is somatic and maintained by reinforcement. Muscular tension and associated GSR are parallel events arising from a common cause. That is, combined bracing - GSR functions as a unitary process, the acquisition of which depends upon the somatic aspect and thus reinforcement. Existence of the GSR response is due to the somatic bracing response. But the GSR could be subtracted from this process leaving the somatic response intact. The GSR is thought to be a by-product or secondary phenomenon. The same notion is also said to hold true for other autonomic responses. So in this context Smith was arguing for what he felt a more parsimonious unitary theory of learning. Curiously enough, it appears he questioned the significance of pure classical (not operant) conditioning of visceral responses suggesting that some classical components may arise through mediating operants.

Moreover, Church (1964) shed additional light on the use of the yoked control design used in operant conditioning of ANS. He stated that:

> ...As in other experimental designs, individual differences result in random errors, but in the yoked control design individual differences also may produce a constant error that cannot be reduced by increasing the number of observations (Church, 1964, p. 122).

The implications of the above contention were discussed for both positive and negative reinforcers. A positive reinforcer may increase responding of some subjects more than others. Accordingly, experimental subjects may have responded more frequently than their matched controls. There may be individual differences in the effectiveness with which a reinforcing stimulus increases the probability of a particular operant.

With regard to negative reinforcers, it was noted that systematic differences between experimental and control groups may arise even if the temporal relationship of response to punishment were irrelevant. For example, if prior to response cessation the experimental subject requires several more punishments than its control, only a small difference favoring the experimental subject will emerge. However, if the control requires several more punishments than the experimental subject, the control will not terminate responding. A suggested alternative to the yoked control is to employ independent groups trained with differing intervals of delay between response and reinforcement to determine relevancy of the temporal relationship of the two variables. To determine if frequency of reward is responsible for observed effects, independent groups with differing reinforcement frequencies or schedules may be utilized. The consequences would be reduction of random errors that lead to systematic effects.

In addition to other criticisms, Schwartz (1973) suggested that instrumentally the two nervous systems (autonomic and central) appear unitary. However, classical and operant conditioning of autonomic responses are dependent on differing cortical mechanisms. This is supported by the fact that removal of the neocortex in rats results in failure of instrumental, but not classical, conditioning of cardiac rate (Di Cara, Braun, and Pappas, 1970).

On the opposite side of the coin, Kimmel (1967) asserted apparent instrumental conditioning of the ANS. He contended that in the case of reward training, critical issues of design and somatic mediation have been dealt with adequately. To support this he pointed to the work of Neal Miller and his colleagues with Curarized rats as demonstrating acquisition of several visceral responses.

Crider, Schwartz, and Schnidman (1969) questioned the criterion employed by Katkin, Murray and others in rejecting instrumental conditioning of the ANS. Mediation, both peripheral and congnitive, were purported to be unlikely explanations for the results. This notion is supported by experimental evidence which indicates that instrumental reinforcers are not powerful enough to classicaly condition ANS responses (Kimmel, 1964, Fowler and Kimmel, 1962, Kimmel and Kimmel, 1963). Moreover, Shapiro, Crider and Tursky (1964) were unable to detect differences between reinforcement contingent and non-contingent subjects in either a perceived association between cognitive events and a reinforcer, or in sustenance of ideational activity over time.

Crider, Schwarts and Schnidman (1967) also suggested critics have been too harsh in evaluating acquisition effects. They did not adhere to the necessity of demonstrating an increased response frequency over free operant level as did Katkin and Murray (1968). Crider et. al. (1967) maintained acquisition is illustrated by demonstration of an increase in probability of responding with contingent reinforcement, even if significant increases above free operant level are not manifest. Moreover, they posited that yoked control designs do not automatically invalidate research in which they are utilized.

Experimental evidence which appears to negate some of the critic's attacks is available.

With regard to the mediation issue Hnatiow (1971) in a fairly well controlled study of this nature, failed to support its existence. Two groups of subjects were involved. The experimental group was provided with a meter giving continuous feedback on systolic blood pressure changes and instructed to keep the readings as steady as possible. The control subjects viewed similar displays inclusive of a tracking task. Analysis of blood pressure data did not indicate experimental subjects as manifesting a significantly larger reduction in variability than controls. However, from feedback to no-feedback trials the experimental group did display a significant reduction in blood pressure. Further analysis seemed to indicate some relationship between success on blood pressure task and heart rate; successful subjects manifesting higher heart rates than unsuccessful subjects. Finally, analysis of respiratory data was non-significant.

This was in accordance with the work of Engel and Hansen (1966) who did not find heart rate responses to be mediated by changes in respiration. Neither did Defran, Badia and Lewis (1969) find instrumental GSR conditioning to be mediated by respiration.

Moreover, autonomic responses have shown: 1) increases over free operant level; 2) they can be brought under control of a discriminative stimulus; 3) some may be brought under control of an aversive stimulus in escape, avoidance, and punishment paradigms (e.g., mostly animal studies) and 4) more resistance to extinction under partial reinforcement (DiCara, 1971, Miller, 1973, Greene, 1966, Grings and Carlin, 1966). Thus it appears Katkin and Murray's criterion of response increase over free operant level as well as other factors specific to operant procedures have some probability of being met. However, no systematic data that would negate criticism of the yoked control design appears available.

In summary, evidence seems to exist both pro and con regarding instrumental conditioning of ANS. It may be noted that the critics responses center around the issue of mediation both peripheral and cognitive, feasability of the yoked control design, and minimal criterion which operant procedures should demonstrate. For some of these attacks plausible evidence of the antithesis appears. For other issues, such as what constitutes a control group or validity of the yoked control, systematic reliable evidence, seems nil. In fact, the extent to which much of the existing research of this nature has been adequately controlled appears to be the pervasive question both for those who ask it, and those who attempt to answer it.

V

For many the existing argument over feasibility of ANS conditioning does not appear as relevant as do the practical implications of said consequences.

Given one accepts instrumental conditioning of ANS as valid, additional therapeutic procedures become visible. The realm of behavior modification is somewhat widened.

To Miller (1969) the demonstration of a dallicious distinction between two types of nervous systems and two concomittant forms of learning has enhanced man's future. Voluntary control of involuntary functions suggests new improved techniques for maintaining homeostasis. In addition, the impact of many physiological disorders involving such responses as heart rate, blood pressure, respiration,

brain waves, urine formation may be brought under control, austensibly minus medication. Moreover, psychological disorders with physiological or involuntary components may be modified (e.g. psychosomatic disorders).

Kamiya (1968) purported other future possibilities. For example, it may become possible to examine a patient's physiological state and diagnose; then modify his neurosis.

Medical World News (1973) delineated additional therapeutic functions. For instance, hand warming can be learned through learning to increase blood flow to the hands at will. Temperature feedback combined with relaxing phrases can be used to control migrane headaches. Electromyographic feedback has been used to treat hemiplegia, paraparesis, asthma, and related disorders. Electroencephlogram feedback has been used to treat epileptics to control the onset of seizures.

The conception of certain psychologically based illness as learned is not new (Brady and Lind, 1961), Turnbull, 1962). What is new is the use of said procedure on the responses mentioned and the general ramifications implied.

Some authors have pointed to the case of operant versus classical conditioning, such as Walker (1967). Presumable plausible operant conditioning should more readily facilitate learning of visceral responses of therapeutic import.

Most dramatic is the recognition that physiological and psychological components are not distinct, but rather interrelated processes. For example, many disorders labeled "psychological" have as underlying or parallel entities, physiological responses. Thus, these physiological responses could also be subjected to operant procedures as an extenuation of treatment. Pure medical benefits have heretofore been spelled out.

VI

In conclusion, a number of comments appear necessary. First, it is disappointing to note the whimsical manner with which operant advocates relate ANS conditioning to the issue of one versus two learning factors. Apparent control of the operant paradigm over ANS responses is boldly accepted as proof of one factor (DiCara, 1971). In most instances, the discussion ends here with no provisions for an indepth analysis. Moreover, discussion of the ramifications for behavior modification appear almost void. Some authors do discuss the advantages of operant procedures on ANS for therapy. However, no technical analysis on one versus two factors seems to be provided in this context. One is left with a dilemna. Should one regard operant conditioning of ANS as a more possible additive to existing treatment procedures or view it as the <u>one</u> form of learning which should embrace all treatment? These matters appear relevant and still open to question.

In a more theoretical vein one is left with the difficulty of evaluating DiCara's thesis for <u>one</u> kind of learning and the experimental evidence he and others have provided. Even one time proponents of two factors believe future research may well discount this notion (Gantt, 1974).

It appears the crucial question is not whether operant conditioning of the ANS is possible. Abundant experimental evidence exists to suggest that it is. What may be more pertinent is examination of its theoretical and pragmatic values. What does accepting DiCara's position do philosophically to psychological theory and its inherent application?

Feigel (1949) has devised five criteria of the scientific method as standards with which to evaluate a theory.

First, the criteria of intersubjective testability, the requirement that the knowledge claims of science be in principle capable to test. This appears viable to the extent the principles in question have been operationally defined and tested. Many studies, but not all, have rejected the null hypothesis.

Second, reliability or a sufficient degree of confirmation is a criteria. Many authors would agree that operant conditioning of the ANS has been reliably demonstrated. In line with the critics, this appears somewhat subject to question, upon examination of experimental procedures. In addition to the criticisms of Katkin and Murray (1968) one may raise other complaints. For example, many studies establish control of the operant paradigm over ANS responses. Acquisition is then taken as proof of conditioning, extinction data being absent, unrecorded or more often present in animal, but not human studies. Yet, Ferster and Perrott (1968) suggest extinction and reacquisition as being demonstrative of conditioning. Moreover, when extinction data is available it is of the traditional type. That is, the previously effective response becomes ineffective in producing the reward (Davenport, 1969). In this context, it would also be interesting to see an extinction procedure where a response which was previously necessary to produce a reward would become unnecessary. That is, both R^{D} s and R^{Δ} s would be rewarded (Davenport, 1969).

The application of punishment-suppression, escape, and avoidance paradigms to ANS responses would also be of interest, as it appears few such instances exist. These suggestions put to practice could further enhance reliability and validity data as regards the topic.

Third, there is definiteness and precision. Most researchers of ANS conditioning appear definitive of the hypotheses being tested. However, precision might be improved on by utilization of additional and improved monitering devices. These could aid in feedback efforts and the detection of subtle "would be" somatic mediators.

Fourth, coherence and systematic structure is important. Here many theorists would purport a one factor approach involving operant conditioning of voluntary and involuntary processes is more parsimonious.

Fifth, comprehensiveness or scope of knowledge is relevant. In the pragmatic sense comprehensiveness appears a most pertinent variable. Therapeutic procedures can become complex. For example, the therapist must distinguish between acquisition and extinction of previously acquired behavior. For some phobic responses not only must anxiety be extinguished but the previously suppressed response must be selectively reinforced. Careful analysis must be made of any other contingencies which might be present, as punishment and avoidance paradigms only identify what responses will not occur.

It is also feasible to identify response clusters, since one response unit can collapse into a chain of responses. The therapist is not dealing with a single response, but a single response consisting of more elements. Although questionable for some it is still probably that a response at the beginning of the chain could have been elicited by a classical procedure and then followed by reinforcement.

Whether reinforcement theory alone can answer all these complexities is somewhat open to question. As previously mentioned punishment, avoidance and escape paradigms have yet to abound the literature on operant conditioning of ANS. Of course, the proponents may argue that one does not have sufficient experimental evidence to doubt reliable establishment of such procedure. By the same token one does not have abundant evidence to clearly embrace the validity and reliability of such.

Moreover, one may find it very convenient to at least maintain the existence of a procedural distinction between classical and operant conditioning. The therapist may find it feasible to use classical procedures to shock an undesirable response. Whether an operant paradigm can suffice for all these procedures in the therapy situation has yet to be unquestionably demonstrated.

It thus appears that one may assume the role of "Doubting Thomas" and most safely conclude both therapeutic convenience and success rest with acknowledgement of two kinds of learning. On the other hand, one may assert that reinforcement appears to hold promising practical implications for control of ANS functions. But until future research dispels the need for positive effects of both procedures, it may only take its place as an additional treatment tool, not a negation of some present practices.

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